BUBBLE FIELD CHARACTERIZATION USING THE AMBIENT SOUND FIELD

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LONG-TERM GOAL

The ambient sound field contains information about the processes generating the sound and the intervening media modifying the sound. This research seeks to demonstrate measurement of useful geophysical processes using passive measurements of the ambient sound field. This will allow passive monitoring of environmental conditions from simple and robust sensors, namely hydrophones.

SCIENTIFIC OBJECTIVES

The ambient sound field measured at a point consists of the sound generated by a distributed sound source after transmission through the media to the measurement point. In the ocean, one feature of the intervening media are ambient bubbles. These bubbles attenuate sound principally at their resonant frequency. Thus, measurement of frequency dependent sound attenuation along known transmission paths can be used to measure the ambient bubble size distribution. If the distributed sound sources are known, through measurement or prediction, then passive monitoring of the sound field away from these sources can be used to measure the ambient bubble size distributions.

APPROACH

This experiment took place in the vicinity of the Scripps Institution of Oceanography (SIO) Pier as part of a larger experiment, "The Influence of Bubbles on Naval Systems Operating in Shallow Water (Caruthers, NRL)." At the SIO pier, the distributed sound sources are the bubbles from actively breaking waves in the surf and snapping shrimp living on the pier pilings. In fact, at the SIO pier, the sound of the shrimp dominates the sound field over 3 kHz. Ambient sound measurements were made on a tower 40 m north of the pier, beyond the NRL experiment, and generally outside of the active breaking surf zone. Thus, the intervening "media" is the bubbly water between the 1) surf zone and the tower, and 2) the bubbly water between the pier and the tower. The bubbly water between the pier and the tower was sampled as part of the NRL experiment using active acoustic measurements. By directly measuring the sound field along the pier, the integrated sound source field of the breaking surf zone and the shrimp can be determined.

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Given this distributed sound source field, the attenuated sound field at the tower can then be used to measure the attenuation through the bubbly water. This attenuation is assumed to be due to an ambient bubble population. The ambient bubble population is then estimated and compared to the results of the active acoustic instruments.

WORK COMPLETED

Approximately 2500 ambient sound spectra spanning the frequency range 0-100 kHz were collected over seven days of the experiment (6-12 March 1997). These included spectra at various locations along the pier and at the observation tower 40 m north of the pier. Approximately 1000 short duration (1-10 sec), high sampling rate (200 kHz) time series were collected during the experiment. The sound from individual breaking waves within the surf were recorded. Well identified shrimp "snaps" along the outer portions of the pier were also recorded. These "signals" can be used as broad-band acoustic sources to track propagation along the pier and from the pier to the observation tower. Low frequency ambient sound time series were also collected at selected times during the experiment. Simultaneous video tape of the wave field and high frequency sound spectra were recorded. Thus, the structure of the low frequency sound field and the wave field can be incorporated into the description of the high frequency ambient sound field.

RESULTS

Limited analysis has occurred. Preliminary results show that sound generation events, e.g. breaking waves, within the surf zone are acoustically isolated from one another to frequencies well below 1 kHz. In other words, no high frequency acoustic propagation occurs within the surf zone. Outside of the surf zone, snapping shrimp dominate the sound field. These events are discrete, identifiable, and can be tracked over 50 m. Using the sound signal from the shrimp snaps, frequency dependent acoustic attenuation is observed during bubbly water conditions, including rip current events, between the pier and the observation point 40 m north of the pier.

IMPACT/APPLICATIONS

Analysis of the ambient sound field to provide useful geophysical fields, such as the ambient bubble size distribution, will lead to advances in our understanding of physical processes within the environment and will improve the predictability of performance of instrument systems that operate in these environments.

RELATED PROJECTS

This experiment was part of a much larger experiment, "The Influence of Bubbles on Naval Systems Operating in Shallow Water." This experiment had many components using both active and passive acoustic instrumentation. Other participants included Caruthers/Stanic (NRL), Farmer (IOS), Melville (SIO), Grant (SIO), Dahl (APL), Henyey (APL), Su (NRL) and Heitmeyer (NRL).